

## Preventing Confined Space Accidents

Confined space accidents continue to cause occupational deaths in Michigan. Such deaths are disturbing because they are preventable.

### MELVINDALE INCIDENT

A case in point were the needless deaths in 1976 of two senior inspectors for the Detroit Water Department whose bodies were found floating in a foot of water in an underground vault housing water meters in Melvindale. They reportedly had been checking the meters when they were felled. Had they used the proper procedures for entering and working in confined spaces, they would have encountered no problem.

The cause of death in this incident was asphyxiation from reduced oxygen which resulted from methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>) formation in the underground vault.

Overcome in the meter pit, the men were underground about six hours before they were found. A study of the atmosphere was conducted by Michigan Department of Public Health personnel to determine the quantities of gases present in the pit. Results showed that the percentage of oxygen had decreased as the CH<sub>4</sub> and CO<sub>2</sub> accumulated to form a non-respirable atmosphere.

Water seeping into a poorly ventilated area such as this contains organic material which is decomposed by aerobic bacteria to produce CO<sub>2</sub> and CH<sub>4</sub> gases. Anaerobic bacteria may take over when the oxygen is depleted to form reduced sulfur compounds such as hydrogen sul-

fide, also found in underground pits and wells.

Two most important occupational health rules for confined space entry were violated in the Melvindale incident:

1. Workers failed to test for a respirable atmosphere before entering the pit.

2. The pit was not mechanically ventilated prior to entry, or while employees were in the pit.

And there were violations of the rules that apply when entry must be made without testing and ventilating:

1. There were no standby personnel on the surface equipped to perform emergency rescue.

2. Self-contained breathing apparatus and lifelines were not worn by the employees entering the pit.



DEATH LURKS IN CONFINED SPACES

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Atmospheric Test Data <sup>1</sup> Detroit Water Meter Vault Melvindale, Michigan					
DATE	O <sub>2</sub>	N <sub>2</sub>	CH <sub>4</sub>	C <sub>2</sub> H <sub>6</sub>	CO <sub>2</sub>
Sept. 2, 1976	21%	—	0.08%	—	0.04%
Sept. 7, 1976	20.0%	76%	0.4%	0.009%	2.0%
Sept. 16, 1976	15.4%	76.8%	3.0%	0.05%	4.0%
Sept. 22, 1976	14.4%	79.0%	2.6%	0.06%	5.0%
Sept. 30, 1976	10%	80.5%	2.9%	0.03%	5.7%
Non-respirable					

<sup>1</sup>Manhole sealed for testing Sept. 7, 1976



*Entrance to Melvindale meter pit.*

(periodic atmospheric testing) was performed.

When inert gases are used to purge or blanket a tank or welding process, the possibility of gas buildup in confined spaces is great unless proper ventilation of the area is provided. In this instance, a continuous, centrally located oxygen monitor with multiple test points and an alarm would have alerted personnel to an oxygen level less than 19.5 percent by volume.

## MIDLAND POWER PLANT INCIDENT

Death was cheated by moments at a large power plant under construction near Midland.

A large horizontal-feed water tank had contained an inert nitrogen atmosphere (nitrogen blanket) for twelve months to minimize corrosion. An employee entered through one end of the tank to perform work in the interior and failed to notify the foreman. No ventilation, atmospheric test, or safety equipment were provided prior to entry. The man collapsed six feet from the manhole. His helper, who crawled in to help, also became dizzy. He rushed to the manhole and yelled for help. A third man ran up a nearby hill and notified a fourth person who, in turn, ran to the first aid station. Men with proper equipment were immediately dispatched. The first man who had entered the tank was rescued and returned to work the following day.

Violation of Michigan's occupational health confined space entry rules R3301 and R3302 were obvious in this case. Ventilation, testing, safety equipment, res-

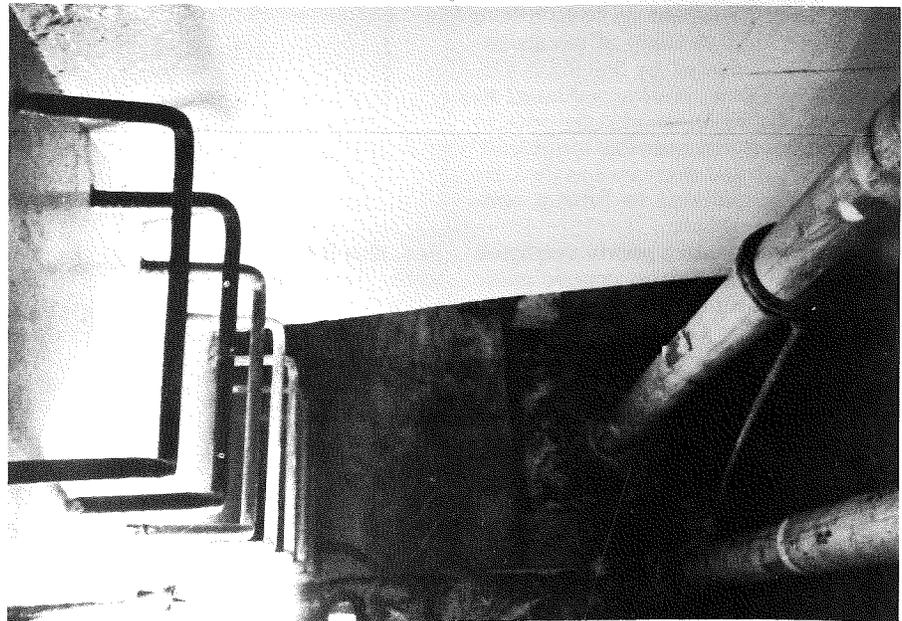
## BRIDGMAN INCIDENT

A similar incident involving fatalities in a confined space occurred in 1976 at a nuclear power plant under construction at Bridgman.

Seven men were working as pipefitters in an area which had a volume of 800 to 1,000 cubic feet of air space. Argon gas in use for inert gas welding of stainless steel had leaked into the area and caused the asphyxiation and collapse of all of the men. One man expired in the confined space; the others required medical treatment. One died the next day.

Could this accident have been averted?

Argon, an inert gas weighing 1.38 times as much as air, had leaked into the work area and displaced the air. In this case, the difference in weight between the argon and the air was not as significant as the fact that it was coming from a pressurized, seemingly unlimited supply. The men had no way of knowing this was happening, since no oxygen monitoring



*Entry into sump area where fatalities occurred.*

piratory protection, and standby emergency procedures requirements were not followed prior to entry.

The incident had a favorable outcome, but only because the third man ran to get help instead of trying to go into the tank unequipped for rescue.

## CONCLUSION

Good tank entry procedures should always include the following:

1. Testing of atmosphere for presence of normal (20-plus percent) of oxygen (O<sub>2</sub>) and absence of toxic or combustible gases.

2. Mechanical ventilation of the space prior to entry.

3. Establishment of emergency rescue procedures and procurement of rescue equipment.

4. Tank or vessel entry permit should be completed and posted visibly at the tank entrance.

5. Lock-out of electrical control circuits and the blanking of pipe flanges or the complete disconnection of pipes. Chained valve wheels and locked valve motors have not proved 100 percent reliable.

6. Standby personnel should be placed to observe the worker(s) in the vessel.

In addition to instructing employees in safe procedures for entry into confined

spaces, it is recommended that a tank entry permit system or entry log sheet be established. Entry permits are more appropriate for itinerant jobs; log sheets may be more suitable for repeated reentry at fixed locations. The purpose in either case is to establish safeguards against confined space accidents resulting from inadequate training and/or supervision and lapses of memory or good judgment by oldtimers. Examples of permits and logs are printed elsewhere in this issue of Michigan's Occupational Health. An additional suggestion: at the time a manhole is opened and during preparations for entry, post a "hazardous atmosphere" warning sign at the site to prevent any unauthorized entry.

# Occupational Health Guide C

## CONFINED SPACE ENTRY (Except Tunnels)

Michigan occupational health standards administered by the Department of Public Health include requirements for entry into confined or enclosed spaces. The requirements are summarized, and guidelines for entry of all such places—except tunnels, which are covered by separate and specific rules—are as follows:

### EMPLOYERS' RESPONSIBILITIES

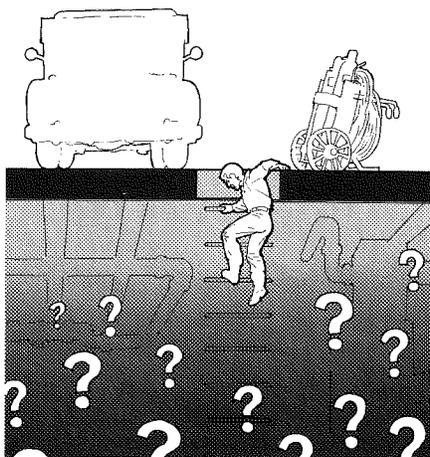
The employer shall instruct all employees in the nature of the hazards involved, the necessary precautions to be taken, and in the use of protective and emergency equipment required. The employer shall also comply with any specific Michigan Department of Labor Construction Safety and General Industry Safety regulations that apply to work in dangerous or potentially dangerous confined or enclosed spaces.

The term confined or enclosed space, for the purpose of this guide, means any space having a limited egress (exit), which is subject to the accumulation of toxic or flammable contaminants or the development of an oxygen deficient atmosphere. Confined or enclosed spaces include, but are not limited to: storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open top spaces more than

four feet in depth such as pits, tubs, vaults, and vessels. Specifying limiting dimensions can be misleading; air quality in the employee's breathing zone is the important factor.

### ENTRY STRATEGY

Michigan occupational health standards (rules) require that certain specific precautions be employed before and during entry of a confined or enclosed space.

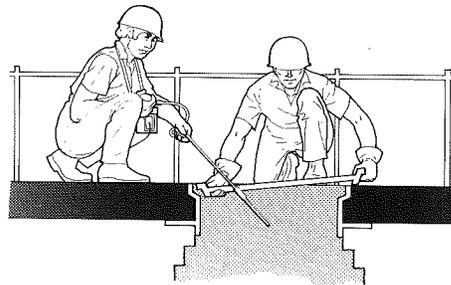


*Is it safe to enter?*

Certain additional procedures not included in the rules are so important or

useful that they have been included as guidelines. Please note the distinction between mandatory and advisory language.

1. Prior to employee entry, appropriate tests of the atmosphere shall be made to determine if established air contaminant limits are exceeded, or if the oxygen concentration is less than 19.5 percent by volume. (A listing of instrument manufacturers is available upon request). The testing should be done by a qualified person who is familiar with instrument operation and checking, and air testing procedures.



*A test of the atmosphere should be made before entering confined spaces.*

For dependable test results, the instrument should be calibrated at regular intervals and should undergo periodic maintenance checks. To insure more re-

sponsible testing, it is recommended that a permanent log of the test results and instrument-checks be established and maintained. See Figures 1 and 2.

2. If tests indicate the atmosphere is unsafe, it shall be ventilated until the hazardous atmosphere is removed prior to employee entry.

monitoring of the atmosphere in the confined space and/or continuation of the ventilation.

Some dilution ventilation information is contained in the A.C.G.I.H. Manual, Industrial Ventilation (source information available upon request). It also contains information about fan types, selec-

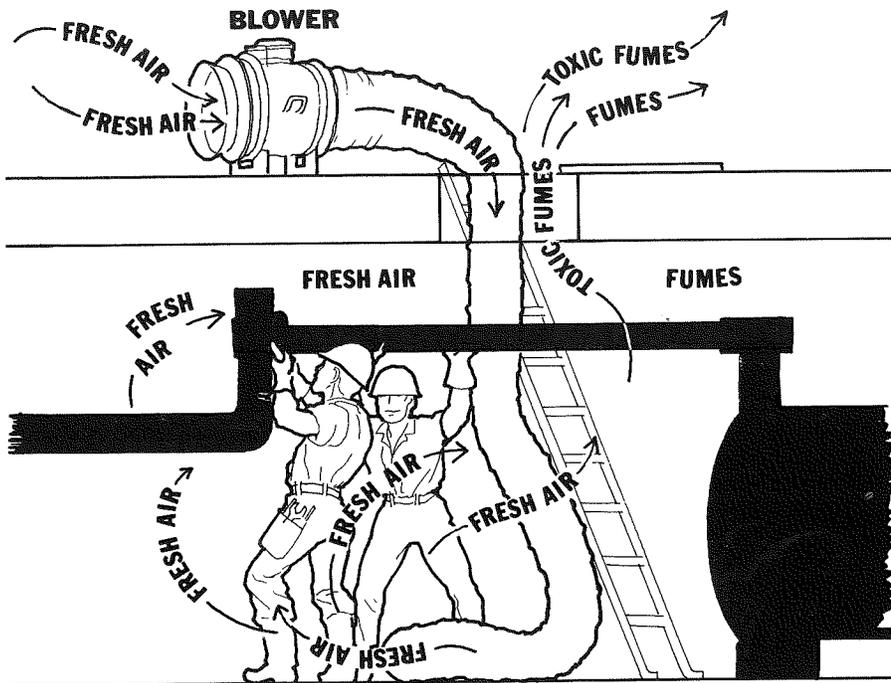
The hose manufacturer should be able to supply friction loss information for his products.

After selection and procurement of equipment, a test run of the assembly is recommended to check operation and air volume to prevent possible problems at the site.

Exercise caution to prevent recirculation of exhaust air or contamination of the ventilation supply. A common contamination source is the exhaust from portable gasoline engines.

If ventilating at a street opening, appropriate warning signs shall be promptly set up when covers of manholes, hand holes, or vaults are removed. An appropriate sign depends upon the nature and location of the hazards involved. Before an employee enters a street opening such as a manhole, it shall be promptly protected with a barrier, temporary cover, or other suitable guard.

4. Confined space entry requires definite procedures. Supervisory authorization should be obtained before entering tanks or other confined spaces. Entry permits have been adopted by experienced employers for this purpose (see Figure 3). A related need, when confined or underground spaces are entered, is a means of promptly determining who is in the confined space. Considering the circumstances of an emergency rescue situation, the desirability of an instantly available check-in, check-out system at the point of entry should be apparent. (Tunnel rules require that an accurate record of the employees underground be



Proper ventilation should be provided to maintain a respirable atmosphere.

3. Precautions shall be continued to prevent the occurrence of a hazardous atmosphere while an employee is in the confined space. This may mean frequent

tion, and good and bad fan inlet and outlet connections. When flexible hose is to be used with a fan, its extra resistance to flow must be considered in sizing the fan.

Figure 1

Example of Repeated Fixed Location Entry Log

XYZ Company Procedures

1. Before personnel are permitted to enter \_\_\_\_\_ (confined space), at location \_\_\_\_\_, the oxygen level shall be measured with an oxygen indicator prior to entry. A minimum of 19.5% oxygen will be required for entry.
2. Before entry of the above described space, a combustible gas indicator shall be used to determine that combustible vapors are not present above 5% of the lower explosive limit.
3. The (confined space) will be identified as being acceptable for entry after conditions (1) and (2) above are satisfied, and this information will be recorded below and signed by a trained authorized person.
4. An air-line respirator with full face mask and 5 minute escape air supply and safety harness will be worn by the person entering the \_\_\_\_\_.
5. Entry will not be made until standby man has checked out self-contained breathing apparatus and moved portable winch and lifting line to eyebolt position over hatch.

Oxygen Meter Check Out	Oxygen Level	Combustible Gas		Time	Date	Authorized Personnel Signature
		Inst. Check	% L.E.L.			

kept on the surface at all times).

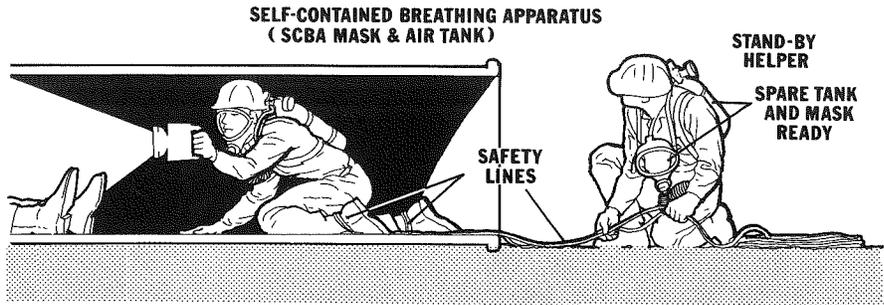
5. In the absence of ventilation or testing, or if tests indicate a non-respirable atmosphere, a person trained in the use of protective equipment shall be equipped with an approved supplied-air respirator or self-contained breathing apparatus, safety harness, and lifeline before entry. The employee shall also wear protective clothing if the contaminant can cause dermatitis or can be absorbed through the skin. Smoking shall be prohibited if the atmosphere is judged to be potentially explosive or flammable.

Written procedures shall be prepared covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations or emergencies. Personnel shall be familiar with these procedures and fitted and trained in the use of respirators.

"If there is a possibility of oxygen deficiency, a self-contained breathing apparatus or hose mask with blower shall be used . . ." While former hose mask approvals may still be in effect, they cannot be recommended for use in locations immediately dangerous to life or

health. This is because they have the same potential for failure as any airline device, i.e., line rupture or air source failure and the inadequacy of the original approval schedule's air flow specifica-

removal of employees in case of emergency. When safety harnesses and lifelines are used, they should be specially attached to the employee so that his body cannot be jammed in the exit opening.



Proper means of rescue are necessary for employees working in confined spaces.

tions for heavy work. Employees in concentrations of air contaminants greater than Maximum Allowable Concentrations (MAC) are required to wear respirators adequate to reduce their exposure to safe limits. A separate publication, Respirator Selection Guide, is available upon request.

An attendant with a pre-planned rescue procedure shall be stationed outside to observe the employee at all times. He shall be trained and equipped to initiate rescue operations. It should be recognized that a single person can seldom raise a limp body, even if a lifeline is attached, without a mechanical aid. This rule is interpreted to mean that without

6. Means shall be provided for quick

Figure 2

Example of Confined Space Entry Log

Personnel Inside Confined Area	Job Assignment	Location
1. Jones	Spademan	Shaft A
2. Smith	Spademan	Shaft A
3. Roberts	Mucker	Shaft A

Date 10/23/76

Person In Charge Adams, C. Foreman

Ventilation in place and Operating yes  
Personnel on standby for emergency

Observer: Adelman, On Call Heinkle and Walters

Date	Time of Test	Time Out	Location or Designation	Instrument		Combustible Gas Indicator %LEL	Oxygen Indicator % O <sub>2</sub>	Compressed Air Carbon Monoxide
				CGI	O <sub>2</sub>			

SIGNATURES OF PERSONNEL IN CONFINED AREA:

Personnel                      Time In                      Time Out

such a device additional manpower must be within easy summoning distance. It is also interpreted to require approved air-supplied respiratory protection for the rescuer, if he must enter the confined space to perform rescue.

Communications (visual, voice, or signal line) shall be maintained between both or all individuals present. Planning shall be such that one individual will be unaffected by any likely incident and have the proper rescue equipment to be able to assist the other(s).

## SPECIAL STRATEGY FOR WORKING IN SEWERS AND SEPTIC SYSTEMS

All of the above requirements and precautions assume a relatively static, predictable situation. Active sewers and sumps containing septic wastes are subject to unpredictable fluctuation in toxic and/or combustible gas liberation. Even though pre-entry testing and ventilating are performed, it is recommended that entry be made wearing supplied-air res-

piratory protection and carrying portable gas and oxygen detection instruments.

## SPECIFIC OPERATIONS

The Michigan occupational health standards have special requirements for certain specific operations.

1. WHEN WELDING, CUTTING, OR HEATING is done in a confined space, either general mechanical or local exhaust ventilation shall be provided to prevent the accumulation of toxic materials or possible oxygen deficiency. This applies to helpers as well as welders. When sufficient ventilation cannot be obtained without blocking the means of access, employees in the confined space shall be protected by airline respirators or self-contained breathing apparatus. An employee on the outside of such a confined space shall be assigned to maintain communications with those in the confined space and to aid in an emergency. When safety belts and lifelines are used for the purpose of removing the welder in an emergency, they shall be attached so that his body will not be jammed in the exit opening.

2. WHILE WORK IS BEING PERFORMED IN MANHOLES, an employee shall be available in the immediate vicinity to render emergency assistance that may be necessary. This shall not prevent the employee in the immediate vicinity from occasionally entering the manhole to provide assistance other than in emergency. This means that a qualified employee working alone, who can enter safely for brief periods of time, may enter a manhole where energized cables or equipment are in service. Such entry may be made for the purpose of inspection, housekeeping, taking readings, or similar work.

Before using open flames or smoking in a manhole where combustible gases or liquids may be present, such as near gasoline stations, the atmosphere of the manhole shall be tested and found safe. When open flames must be used or smoking is permitted, extra precaution shall be taken to provide adequate ventilation.

3. DURING VESSEL ENTRY IN PULP, PAPER, AND PAPERBOARD MILLS, lifelines and safety harnesses shall be worn by anyone entering closed vessels, tanks, chip bins, and similar spaces. A person shall be stationed outside in a position to handle the line and to summon assistance in case of emergency. The air in the vessel shall be tested for oxygen deficiency and the presence of a hazardous atmosphere before entry is permitted. Self-contained air or oxygen supply masks shall be readily available in case of emergency. Work shall not be performed on equipment under conditions

Figure 3

### Example of Vessel Entry Permit

#### ENTRY PERMIT

This permit must be completed before entering any vessel for cleaning, inspection or maintenance work. It must be displayed at the vessel during the entire time anyone is in the vessel.

This will authorize the \_\_\_\_\_ Department  
 To enter \_\_\_\_\_ Equipment Name and Number  
 Location \_\_\_\_\_ (building) \_\_\_\_\_ (Area)  
 From \_\_\_\_\_ AM PM to \_\_\_\_\_ AM PM  
 \_\_\_\_\_ (Date)

Purpose of entering \_\_\_\_\_  
 Ventilation required \_\_\_\_\_

This permit valid for only one shift and must be executed on that shift prior to starting work.

I have personally inspected this vessel or area and

1. Explosion meter tests have (not) been made.
2. Oxygen deficiency tests were made and a reading of \_\_\_\_\_ per cent was noted.
3. It is clear of flammable, corrosive, and toxic materials.
4. The chemical hazard to guard against is \_\_\_\_\_
5. There are no surrounding conditions to endanger someone in the vessel.
6. All connecting lines have been blanked properly.
7. The lock, tag, and try procedure has been completed.
8. Ventilation equipment working properly.
9. The standby men have been notified and will be furnished as follows:

1st standby \_\_\_\_\_  
 2nd standby \_\_\_\_\_

10. The combustible gas alarm has been tested for sound and distance.

Signature \_\_\_\_\_  
 Shift Foreman

Remarks: \_\_\_\_\_

where an injury could result if a valve were unexpectedly opened or closed, unless the valve has been locked in a safe position.

4. BEFORE ENTRY INTO OPEN SURFACE TANKS, the contents shall be drained and cleanout doors shall be opened where provided. All pockets in tanks or pits where it is possible for hazardous vapors to collect shall be ventilated of such vapors and cleaned. Appropriate tests of the atmosphere shall be made to determine if the Maximum Allowable Concentrations are exceeded or if the oxygen supply is deficient (less than 19.5 percent).

If tests indicate that the atmosphere in the tank is unsafe, before any employee is permitted to enter, the tank shall be ventilated until the hazardous atmosphere is removed, and shall continue to be ventilated to prevent accumulation of hazardous atmosphere as long as an employee remains in the tank. If the contaminant can be absorbed through the skin, protective clothing shall be worn.

At least one trained employee with respirator and lifeline shall be present in the nearest uncontaminated area for standby purposes. The standby employee must be able to communicate with the employee in the tank and be able to haul him out of the tank with a lifeline, if necessary.

## SUMMARY

Confined space accidents all too often result in death for the person entering the space and, very often, for untrained, unequipped rescuers as well. Michigan occupational health rules for confined space are intended to prevent such accidents and resulting fatalities.

Proper and required procedures may be summarized as follows:

1. Provide adequate ventilation to assure a respirable atmosphere with oxygen level of at least 20 percent by volume, and combustible gas concentration below 20 percent of the lower explosive limit (LEL).

2. Test the atmosphere prior to entry and on a regular basis during occupancy to confirm that the oxygen level is 20 percent or greater, the combustible gas concentration is below 20 percent of the LEL, and hydrogen sulfide and other toxic gases are not present in hazardous concentrations.

3. Prevent the development of conditions which may result in a non-respirable atmosphere in spaces occupied by unprotected persons.

4. Before giving employees work or direct supervisory responsibility involving entry into sewers, vaults, or confined or enclosed spaces, train them in the nature of the potential hazards involved, and the precautions and procedures which must be followed.

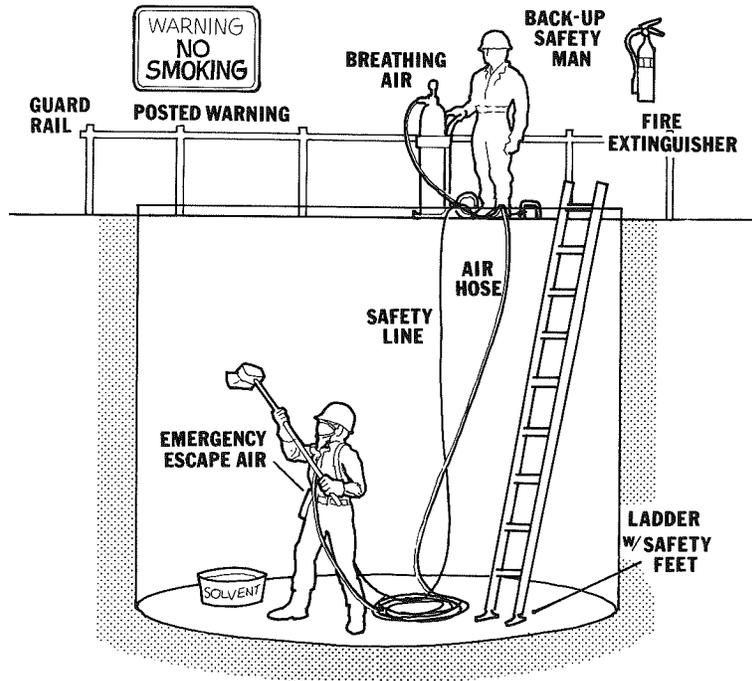
In the absence of ventilation and where tests fail to confirm the presence of a respirable atmosphere, or where conditions cannot be controlled to prevent the development of a non-respirable atmosphere, personnel must not be allowed to enter such spaces unless:

1. Approved air-supplied respiratory protective equipment is furnished and used.

2. Written procedures have been prepared covering the safe use of respirators, and personnel are properly trained in the proper use and limitations of the respiratory protective equipment and the type of hazard which may be encountered.

3. Trained personnel are available and are stationed outside of the space with proper equipment to provide for the rescue of the person(s) entering the space. This will require the use of safety harnesses with provisions for lifting workers from the enclosed space. If entry is required for rescue, the rescue worker must be equipped with approved air-supplied respiratory equipment.

NOTE: This guide is intended for the benefit of the public and may not contain all of the information pertinent to a specific hazard identification and/or control of personnel exposure. For further information, consult the Division of Occupational Health, 3500 North Logan Street, P.O. Box 30035, Lansing, MI 48909. 517/373-1410.



*A standby employee stationed outside a confined space is vital.*

# BULLETIN BOARD . . .

## Training Offering

"Workplace Monitoring," October 4-5, 1977, Oakland University, Rochester. Details from Greater Detroit Safety Council, 857 Virginia Park, Detroit, MI 48202; 313/873-4422.

## Asbestos Standard Updates

Effective March 19, 1976, the U.S. Department of Labor changed the employers airborne asbestos monitoring records retention period to 20 years from the previous requirement of 3 years. This period corresponds with the medical record retention period included in the standard. Michigan adopted the federal asbestos standard by reference, effective January 1, 1975.

In January 1977, the Assistant Secretary of Labor announced a policy change to require medical examinations only when exposures to asbestos fibers exceed 0.1 fibers greater than 5 microns in length per cubic centimeter of air. The previous interpretation of the standard required examination and monitoring no matter how low the fiber concentration.

The above noted interpretations have application to Michigan employers in both the public and private employment sectors and will be applied by the Department of Public Health in the state occupational health program.

## Occupational Health Standards Commission News

The commission was saddened to learn in January of the death of Richard J. Oreson, representative of the Oil, Chemical and Atomic Workers Union and one of the commission's charter members.

The commission is actively engaged in occupational health standards review and promulgation. As required by Act 154 of 1974, advisory committees have been appointed and are working in the following areas:

**Agricultural Health.** This committee was formed to keep abreast of OSHA proposals and standards development in the area of agricultural labor camps, field sanitation, and related issues.

**Coke Oven Emissions.** This committee is evaluating the recent OSHA standard on coke oven emissions, preparatory to the promulgation of the state standard.

**Core.** This committee was formed to monitor OSHA activities in the development of standards covering broad occupational health issues found throughout industry and not confined specifically to one type of operation (horizontal type standards). This committee will shortly be considering a number of air contaminant standards.

**Diving Operations.** This committee is reviewing the current OSHA standard proposal for commercial diving.

**First Aid.** This committee was formed to review federal occupational health first aid standards which were adopted by reference. The intent of the committee is to determine the adequacy of present first aid standards and to develop guidelines to assist employers and employees in meeting the standards' requirements.

**Tunnels.** This committee is reviewing and revising present occupational health standards relative to tunneling operations which were adopted by reference from the federal standards with the passage of Act 154.

Inquiries relative to occupational health standards activities may be addressed to the Occupational Health Standards Commission, c/o James C. Barrett, Commission Secretary, Michigan Department of Public Health, 3500 North Logan Street, P.O. Box 30035, Lansing, MI 48909.

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